GATE 2021

Computer Science & Information Technology

Shift-1

Questions & Solutions

Byju’s Exam Prep App  https://byjusexamprep.com
SECTION: GENERAL APTITUDE

1. A circular sheet of paper is folded along the lines in the directions shown. The paper, after being punched in the final folded state as shown and unfolded in the reverse order of folding, will look like ____.

2. There are five bags each containing identical sets of ten distinct chocolates. One chocolate is picked from each bag.
   The probability that at least two chocolates are identical is ________.
   A. 0.3024  B. 0.4235  C. 0.6976  D. 0.8125

3. Some people suggest anti-obesity measure (AOM) such as displaying calorie information in restaurant menus. Such measures sidestep addressing the core problems that cause obesity: poverty and income inequality.
   Which one of the following statements summarizes the passage?
   A. AOM are addressing the core problems and likely to succeed.
   B. The proposed AOM addresses the core problems that cause obesity.
   C. If obesity reduces, poverty will naturally reduce, since obesity causes poverty.
   D. AOM are addressing the problem superficially

4. A polygon is convex if, for every pair of points, P and Q belonging to the polygon, the line segment PQ lies completely inside or on the polygon.
   Which one of the following is NOT a convex polygon?
Option D is a concave polygon and not a convex polygon.

We have 2 rectangular sheets of paper, M and N, of dimension 6 cm × 1 cm each. Sheet M is rolled to form an open cylinder by bringing the short edge of the sheet together. Sheet N is cut into equal square patches and assembled to form the largest possible closed cube. Assuming the ends of the cylinder are closed, the ratio of the volume of the cylinder to that of the cube is ________.

\[ A. \frac{\pi}{2} \quad \text{B. } \frac{9}{\pi} \quad \text{C. } 3\pi \quad \text{D. } \frac{3}{\pi} \]

The discount on item Q, as a percentage of its marked price, is ________.

\[ A. \ 25 \quad \text{B. } \ 5 \quad \text{C. } \ 12.5 \quad \text{D. } \ 10 \]

The ratio of boys to girls in a class is 7 to 3. Among the options below, an acceptable value for the total number of students in class is

\[ A. \ 50 \quad \text{B. } \ 73 \quad \text{C. } \ 21 \quad \text{D. } \ 37 \]

Details of prices of two items P and Q are presented in the above table. The ratio of cost of item P to cost of item Q is 3 : 4. Discount is calculated as the difference between the marked price and the selling price. The profit percentage is calculated as the ratio of the difference between selling price and cost, to the cost

\[(\text{Profit\%} = \frac{\text{Selling} - \text{Cost}}{\text{Cost}} \times 100)\]

\[ \text{The discount on item Q, as a percentage of its marked price, is } \]

\[ A. \ 25 \quad \text{B. } \ 5 \quad \text{C. } \ 12.5 \quad \text{D. } \ 10 \]
B : G = 7 : 3

\[
\begin{align*}
B &= 7K \\
G &= 3K \\
\text{Total} &= 10K
\end{align*}
\]

So, possible answer is multiple of 10.

So, possible answer is multiple of 10.

\[\Rightarrow 50\]

8. Consider the following sentences:
   (i) Everybody in the class is prepared for the exam.
   (ii) Babu invited Danish to his home because he enjoys playing chess.

Which of the following is the CORRECT observation about the above two sentences?

A. (i) is grammatically correct and (ii) is ambiguous
B. (i) is grammatically correct and (ii) is unambiguous
C. (i) is grammatically incorrect and (ii) is unambiguous
D. (i) grammatically incorrect and (ii) is ambiguous

\[\text{MCQ}\]

Ans. B

Sol. 1st one is grammatically correct and 2nd one is unambiguous.

9. Given below are two statements 1 and 2, and two conclusions I and II.
   Statement 1 : All bacteria are microorganisms.
   Statement 2 : All pathogens are microorganisms.
   Conclusion I : Some pathogens are bacteria.
   Conclusion II : All pathogens are not bacteria.

Based on the above statements and conclusions, which one of the following options is logically CORRECT?

A. Only conclusion II is correct
B. Neither conclusion I nor II is correct.
C. Only conclusion I is correct
D. Either conclusion I or II is correct.

\[\text{MCQ}\]

Ans. B

Sol. C1: All pathogens are not bacteria.
True, if no intersection.
C2: Some pathogens are bacteria.
True, if intersection is these.
So, individually both are false.
But neither of C1 or C2 is correct.

10. _____ is to surgery as writer is to _____

Which one of the following options maintains a similar logical relation in the above sentence?

A. Plan, outline
B. Hospital, library
C. Doctor, book
D. Medicine, grammar

\[\text{MCQ}\]

Ans. C

Sol. Doctor is to surgery as writer is to Book.
1. Let \((M)\) denote an encoding of an automation \(M\). Suppose that \(\Sigma = \{0, 1\}\). Which of the following languages is/are NOT recursive?

A. \(L = \{ M \mid \text{M is a PDA such that} \ L(M) = \emptyset \}\)
B. \(L = \{ M \mid \text{M is a PDA such that} \ L(M) = \Sigma^* \}\)
C. \(L = \{ M \mid \text{M is a DFA such that} \ L(M) = \Sigma^* \}\)
D. \(L = \{ M \mid \text{M is a DFA such that} \ L(M) = \emptyset \}\)

Ans. B
Sol. \(L = \{ M \mid \text{M is a PDA,} \ L(M) = \emptyset \}\) is Recursive
Emptiness is decidable for PDA
L = \{ M \mid \text{M is a PDA,} \ L(M) = \Sigma^* \}\) is not recursive
Totality is not decidable for PDA
L = \{ M \mid \text{M is a DFA,} \ L(M) = \Sigma^* \}\) is Recursive
Totality is decidable for DFA
L = \{ M \mid \text{M is a DFA,} \ L(M) = \emptyset \}\) is Recursive
Emptiness is decidable for DFA

2. In the context of operating system, which of the following statements is/are correct with respect to paging?

A. Paging helps solve the issue of external fragmentation.
B. Page size has no impact on internal fragmentation.
C. Multi-level paging is necessary to support pages of different sizes.
D. Paging incurs memory overheads.

Ans. A,D
Sol. Paging helps solve the issue of external fragmentation.
Paging incurs memory overheads.

3. Consider the following ANSI C program.

```c
#include <stdio.h>
int main()
{
    int i, j, count;
    count = 0;
    i = 0;
    for (j = -3, j <= 3; j++)
    {
        if ((j >= 0) && (i++))
        count = count + j;
    }
    count = count + i;
    printf("\%d", count);
    return 0;
}
```

Which of one of the following options is correct?
A. The program will compile successfully and output 10 when executed.
B. The program will not compile successfully.
C. The program will compile successfully and output 8 when executed.
D. The program will compile successfully and output 13 when executed.

Ans. A
Sol. The program will compile successfully and output 10 when executed.
Ans. A
Sol.

<table>
<thead>
<tr>
<th>j = -3</th>
<th>j = -2</th>
<th>j = -1</th>
<th>j = 0</th>
<th>j = 1</th>
<th>j = 2</th>
<th>j = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3 ≤ 3</td>
<td>-2 ≤ 3</td>
<td>0 ≤ 3</td>
<td>0 ≤ 3</td>
<td>1 ≤ 3</td>
<td>2 ≤ 3</td>
<td>3 ≤ 3</td>
</tr>
</tbody>
</table>

If() False False False True True True True
-1 > = 0 -2 > = 0 -1 > = 0 (1 > = 0) & (I++)

0 1 2 3 4

Count 0 + 0 = 0 0 + 1 = 1 1 + 2 = 3 3 + 3 = 6

Finally,
Count = Count + I; = 6 + 4 = 10
So, Program will compile successfully and prints value 10 after execution.
Hence option ‘A’ correct.

4. Assume that a 12-bit Hamming codeword consisting of 8-bit data and 4 check bits is
d_{8}d_{7}d_{6}c_{8}d_{4}d_{3}c_{4}d_{1}c_{2}c_{1}, where the data bits and check bits are given in

<table>
<thead>
<tr>
<th>Data bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>d_{8}</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Which one of the following choices gives the correct values of x and y?
A. x is 1 and y is 0.  
B. x is 1 and y is 1.
C. x is 0 and y is 0.  
D. x is 0 and y is 1.

[MCQ]
Ans. C
Sol.

<table>
<thead>
<tr>
<th>C_{1}</th>
<th>C_{2}</th>
<th>C_{3}</th>
<th>C_{4}</th>
<th>C_{8}</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>y</td>
<td>x</td>
<td>0</td>
</tr>
</tbody>
</table>

C_{1} : 1 3 5 7 9 11
0 1 0 0 x 1
Forever parity X will be 0, X = 0

5. There are 6 jobs with distinct difficulty levels, and 3 computers with distinct processing speeds. Each job is assigned to a computer such that :
- The fastest computer gets the toughest job and the slowest computer gets the easiest job.
- Every computer gets at least one job

The number of ways in which this can be done is

[MCQ]
Ans. 65
Sol. Let C1 be the fastest and C3 be the slowest computers.
These two are assigned two jobs. Now out of the remaining 4 jobs we need to ensure C2 gets at least
1. Without this constraint we can assign 4 jobs to 3 computers in \(34=81\) ways. Out of these 81 ways \(24=16\) will be having no jobs for C2. So, number of possible ways so that C2 gets at least one job = \(81−16=65\).

6. Let \(p\) and \(q\) be two propositions. Consider the following two formulae in propositional logic.

\[
S_1 : (\neg p \land (p \lor q)) \to q
\]

\[
S_2 : q \to (\neg p \land (p \lor q))
\]

Which one of the following choices is correct?
A. Neither \(S_1\) nor \(S_2\) is a tautology.
B. \(S_1\) is not a tautology but \(S_2\) is not a tautology.
C. \(S_1\) is a tautology but \(S_2\) is not a tautology.
D. Both \(S_2\) and \(S_2\) are tautologies.

**Ans. C**

**Sol.**

\[
p \land (\neg p \lor q) \to q
\]

\[
\neg (p \land (\neg p \lor q)) \lor q
\]

\[
\neg ((p \land \neg p) \lor (p \land q)) \lor q
\]

\[
\neg (F \lor p \land q) \lor q
\]

\[
\neg (p \land \neg q) \lor q
\]

\[
\neg (p \lor \neg p) \lor q
\]

\[
\neg p \lor T
\]

\[
\neg q \lor \neg p
\]

\[
B\] is not tautology

7. Consider the following context-free grammar where the set of terminals is \(\{a, b, c, d, f\}\).

\[
S \to d \text{ a } T \mid R \text{ f}
\]

\[
T \to a \text{ S } \mid b \text{ a } T \mid \epsilon
\]

\[
R \to c \text{ a } TR \mid \epsilon
\]

The following is a partially-filled LL(1) parsing table.

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>f</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>T</td>
<td>T \to a S</td>
<td>T \to b a T</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>R \to c a TR</td>
<td>R \to \epsilon</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Which one of the following choices represents the correct combination for the numbered cells in the parsing ("blank" denote that the corresponding cells is empty)?

A. 1 blank 2 S \to R f 3 blank 4 blank
B. 1 S \to R f 3 blank 3 blank 4 T \to \epsilon
C. 1 blank 2 S \to R f 3 T \to \epsilon 4 T \to \epsilon
D. 1 S \to R f 2 S \to R f 3 T \to \epsilon 4 T \to \epsilon

**Ans. D**

**Sol.**

First (S) = \{d, c, f\}

Follow T) = \{$, c, f\}

First (T) = \{a, b, \epsilon\} \Rightarrow Follow T) = \{$, c, f\}

1. \(M[S, c] = S \to R f\)
2. \(M[S, f] = S \to R f\)
3. \(M[T, c] = T \to \epsilon\)
4. \(M[T, \$] = T \to \epsilon\)

8. Let \(G\) be a group of order 6, and \(H\) be subgroup of \(G\) such that \(1 < |H| < 6\).

Which one of the following options is correct?
A. \(G\) is always cyclic, but \(H\) may not be cyclic.
B. \(G\) may not be cyclic, but \(H\) is always cyclic.
C. Both \(G\) and \(H\) are always cyclic.
D. Both \(G\) and \(H\) may not be cyclic.

**Ans. B**

**Sol.** As order of group is 6 (given) of according to Lagrange’s order of subgroup of group always divides.
i.e. \( O(G) / O(H) \)
\( O(G) = 6 \) (not a prime no)
So, \( G \) is not a cyclic group.
Now, \( 1 < |H| < 6 \) so order of \( H \) may be 2, 3, 4, 5
but only 2, 3 divides 6 so order of \( H \) is either 2 or 3
and both are prime number so \( H \) is cycle group.

9. Let \( P \) be an array containing \( n \) integers. Let \( t \) be the
lowest upper bound on the number of comparisons of the array elements, required to find the minimum
and maximum values in an arbitrary array of \( n \) elements. Which one of the following choices is
correct?
A. \( t > 2n - 2 \)
B. \( t > \lceil \log(n) \rceil \) and \( t \leq n \)
C. \( t \geq n \) and \( t \leq 3 \left\lfloor \frac{n}{2} \right\rfloor \)
D. \( t > 3 \left\lfloor \frac{n}{2} \right\rfloor \) and \( t \leq 2n - 2 \)

\[ \text{[MCQ]} \]

Ans. C
Sol.

Straight – Max Min
Max comp. \( (2n – n \text{ comp.}) \)
Min comp. \( (n – 1) \text{ comp.} \)

10. Consider the following expression.
\[ \lim_{x \to -3} \frac{\sqrt{2x + 22} - 4}{x + 3} \]
The value of the above expression (rounded to 2
decimal places) is______.

\[ \text{[NAT]} \]

Ans. 0.25
Sol. \( (0.25) \)
\[ \lim_{x \to -3} \frac{\sqrt{2x + 22} - 4}{x + 3} = \frac{\sqrt{16} - 4}{-3 + 3} = 0 \] from

Apply L'Hospital Rule,

\[ \lim_{x \to -3} \frac{1}{2\sqrt{2x + 22}} = \frac{1}{2} \sqrt{6} \times 2 = \frac{1}{4} = 0.25 \]

11. Consider the following representation of an number
in IEEE 754 single-precision floating point format
with a bias of 127.

\( S : 1 \quad E : 10000001 \quad F : 11110000000000000000000 \)

Here \( S \), \( E \) and \( F \) denote the sign, exponent and
fraction components of the floating point
representation.
The decimal value corresponding to the above
representation (rounded to 2 decimal places) is

\[ \text{[NAT]} \]

Ans. -7.75
Sol. \((7.75)_{10}\)
\[ N = (-1)^5 \times 1.F \times 2^{128-127} \]
\[ = (-1)^1 \times 1.1111000...0 \times 2^{129-127} \]
\[ = - (1.1111000...0) \times 2^2 \]
\[ = - (111.11000...0)_2 = - (7.75)_{10} \]

12. Consider the following instruction sequence when
register R1, R2 and R3 are general purpose and
MEMORY \([X]\) denotes the content at the memory
location \( X \).

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Semantics</th>
<th>Instruction Size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOV R1, (500)</td>
<td>R1 ← MEMORY [500]</td>
<td>4</td>
</tr>
<tr>
<td>MOV R2, (R3)</td>
<td>R2 ← MEMORY [R3]</td>
<td>4</td>
</tr>
<tr>
<td>ADD R2, R1</td>
<td>R2 ← R1+R2</td>
<td>2</td>
</tr>
<tr>
<td>MOV (R3), R2</td>
<td>MEMORY [R3] ← R2</td>
<td>4</td>
</tr>
<tr>
<td>INC R3</td>
<td>R3 ← R3+1</td>
<td>2</td>
</tr>
<tr>
<td>DEC R1</td>
<td>R1 ← R1-1</td>
<td>2</td>
</tr>
<tr>
<td>BNZ 1004</td>
<td>Branch if not zero to the given absolute address</td>
<td>2</td>
</tr>
<tr>
<td>HALT</td>
<td>Stop</td>
<td>1</td>
</tr>
</tbody>
</table>
Assume that the content of the memory location 5000 is 10, and the content of the register R3 is 3000. The content of each of the memory locations from 3000 to 3010 is 50. The instruction sequence starts from the memory location 1000. All the numbers are in decimal format. Assume that the memory is byte addressable.

After the execution of the program, the content of memory location 3010 is ______.

**Ans. 50**

**Sol.**

At address 1004, the second instruction is present. Instruction from 2\textsuperscript{nd} to 7\textsuperscript{th} are in loop, loop will be terminated when R\textsubscript{1} becomes zero. In the first iteration value at address “3000” will be 60.

In the second iteration, value at address 3001 is 59 and so on.

At the 10\textsuperscript{th} iteration the value of memory location 3009 is 51.

The value “50” remain same at address 3010. So the correct answer is "50".

13. Consider the following C code segment.
    \[
    \begin{align*}
    a &= b + c; \\
    e &= a + 1; \\
    d &= b + c; \\
    f &= d + 1; \\
    g &= e + f;
    \end{align*}
    \]

In a compiler, this code segment is represented internally as a directed acyclic graph (DAG). The number of nodes in the DAG is _______.

**Ans. 6**

**Sol.**

So,Total no. of nodes = 6

Total no. of edges = 6

14. Which of the following standard C library functions will always invoke a system call when executed from a single-threaded process in a UNIX/Linux operating system?
    A. strlen
    B. sleep
    C. malloc
    D. exit

**Ans. B,D**

**Sol.** Sleep (), exit () always invokes the system calls.

Strlen () and malloc () does not always invokes the system calls.

15. Consider a 3-bit counter, designed using T flip-flops, as shown below:

Assuming the initial state of the counter given by PQR as 000, what are the next three states?

A. 001, 010, 111   B. 011, 101, 000
C. 001, 010, 000   D. 011, 101, 111
Ans. B

Sol.

<table>
<thead>
<tr>
<th>CLK</th>
<th>PQR</th>
<th>TFF</th>
<th>PFF</th>
<th>QFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 0 1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2 1 0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3 0 0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The next three states are —
Initial : 000
1st pulse : 011
2nd pulse : 101
3rd pulse : 000
The states sequence is

10. Consider a linear list based directory implementation in a file system. Each directory is a list of nodes, where each node contains the file name along with the file metadata, such as the list of pointers to the data blocks. Consider a given directory foo.

Which of the following operations will necessarily require a full scan of foo for successful completion?
A. Opening of an existing file in foo
B. Deletion of an existing file from foo
C. Creation of a new file in foo
D. Renaming of an existing file in foo

Ans. C, D

Sol. Creation of a New File: For creating new file, we’ve to check whether the new name is same as the existing files. Hence, the linked list must be scanned in its entirety.

Deletion of an Existing File: Deletion of a file doesn’t give rise to name conflicts, hence if the node representing the files is found earlier, it can be deleted without a through scan.

Renaming a File: Can give rise to name conflicts, same reason can be given as option A.

Opening of existing file: same reason as option B.

17. Consider the following undirected graph with edge weights as shown:

The number of minimum-spanning trees of the graph is __________.

Ans. 3

Sol.

18. Consider the two statements.

S1 : There exist random variables X and Y such that
\[
(E[(X - E(X)) (Y - E(Y))])^2 > Var[X] Var[Y]
\]

S2 : For all random variables X and Y,
\[
\]

Which one of the following choices is correct?
A. Both S1 and S2 are true
B. S1 is true, but S2 is false.
C. Both S1 and S2 are false.
D. S1 is false, but S2 is true.

Ans. C

Sol. (E(X - E(X))E(Y - E(Y)))^2 > VAR[X]VAR[Y]

VAR[X].VAR[Y] = E((X - E(X))^2)E((Y - E(Y))^2)

If all the data is the same or equal then we have 0 on both sides of the inequality 0 > 0 is false, S1 is false.

Covariance (X,Y) = E[(X-E(X))(Y-E(Y))]S2 is false.
19. The following relation records the age of 500 employees of a company, where empNo (indicating the employee number) is the key:

\[ \text{empAge} = (\text{empNo, age}) \]

consider the following relational algebra expression:

\[ \Pi_{\text{empNo}} (\text{empAge} \bowtie_{\text{age} \geq \text{age}_1} \rho_{\text{empNo} = \text{age}_1} (\text{empAge})). \]

What does the above expression generate?
A. Employee numbers of all employees whose age is not the minimum.
B. Employee numbers of all employees whose age is the minimum.
C. Employee numbers of all employees whose age is more than the age of exactly one other employee.
D. Employee numbers of only those employees whose age is the maximum.

**Ans. A**

**Sol.**

<table>
<thead>
<tr>
<th>empNo</th>
<th>age</th>
<th>emp No 1</th>
<th>Age 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

Emp No = 4 will not be selected because the condition age > age_1 is not satisfied for this EmpNo.

20. For a Turning machine M, \(\langle M \rangle\) denotes an encoding of M. Consider the following two languages.

\[ L_1 = \{ \langle M \rangle | M \text{ takes more than 2021 steps on all inputs} \} \]

\[ L_2 = \{ \langle M \rangle | M \text{ takes more than 2021 steps on some input} \} \]

Which one of the following options is correct?
A. Both \(L_1\) and \(L_2\) are decidable.
B. \(L_1\) is decidable and \(L_2\) is undecidable.
C. \(L_1\) is undecidable and \(L_2\) is decidable.
D. Both \(L_1\) and \(L_2\) are undecidable.

**Ans. C, D**

**Sol.**

C & D should be correct.

1st Solution : \(p[2] = 5+8+5 = 18\)

2nd Solution : \(p[7] = 18\)


21. Define \(R_n\) to be the maximum amount earned by cutting a rod of length \(n\) meters into one or more pieces of integer length and selling them. For \(i > 0\), let \(p[i]\) denote the selling prices of a rod whose length is \(i\) meters. Consider the array of prices:

\[
\]

Which of the following statements is/are correct about \(R_7\)?
A. \(R_7\) cannot be achieved by a solution consisting of three pieces.
B. \(R_7 = 19\)
C. \(R_7 = 18\)
D. \(R_7\) is achieved by three different solutions.

**Ans. C, D**

**Sol.**

1st Solution : \(p[2]; p[3]; p[2] = 5+8+5 = 18\)

2nd Solution : \(p[7] = 18\)

3rd Solution : \(p[6]; p[1] = 17+1 = 18\)

22. Let \(r(z)\) and \(w(z)\) denote read and write operations respectively on a data item \(z\) by a transaction \(T_i\). Consider the following two schedules.

\[ S_1 : r_1(x) \quad r_1(y) \quad r_2(x) \quad r_2(y) \quad w_1(y) \quad w_1(x) \]

\[ S_2 : r_1(x) \quad r_2(x) \quad r_2(y) \quad w_2(y) \quad r_1(y) \quad w_2(x) \]

**Ans.**
Which one of the following options is correct?
A. $S_1$ is not conflict serializable, and $S_2$ is conflict serializable
B. Both $S_1$ and $S_2$ are conflict serializable.
C. Neither $S_1$ nor $S_2$ is conflict serializable.
D. $S_1$ is conflict serializable, and $S_2$ is not conflict serializable.

[MCQ]

**Ans.** A

**Sol.**

$S_1$

```
T_1  T_2
```

∴ Cycle exist so not a serializable.

$S_2$

```
T_1  T_2
```

∴ Cycle does not exist so it is a serializable.

23. An articulation point in a connected graph is a vertex such that removing the vertex and its incident edges disconnects the graph into two or more connected components.

Let $T$ be a DFS tree obtained by doing DFS in a connected undirected graph $G$.

Which of the following options is/are correct?

A. Root of $T$ is an articulation point in $G$ if and only if it has 2 or more children.
B. A leaf of $T$ can be an articulation point in $G$.
C. Root of $T$ can never be an articulation point in $G$.
D. If $u$ is an articulation point in $G$ such that $x$ is an ancestor of $u$ in $T$ and $y$ is a descendent of $u$ in $T$, then all paths from $x$ to $y$ in $G$ must pass through $u$.

[MSQ]

**Ans.** A

**Sol.**

(A) True

We need at least 2 children so that root is articulation point.

(B) False: This can never happen. Leaf will always have degree = 1.

(C) False: Check option (a) for more information.

(D) False: Below is the reasoning to show how this is false.

If ‘$u$’ is articulation point, then removing ‘$u$’ generates 2 connected components, now there might be a case when $x$ and $y$ will belong to either one of the connected components and hence a path will exist between them without passing through $u$. Thus, Option A is correct.

24. Three processes arrive at time zero with CPU bursts of 16, 20 and 10 milliseconds. If the scheduler has prior knowledge about the length of the CPU bursts, the minimum achievable average waiting time for these processes in a non-preemptive scheduler (rounded to nearest integer) is ______ milliseconds.

[ NAT ]

**Ans.** 12

**Sol.**

```
<table>
<thead>
<tr>
<th></th>
<th>AT</th>
<th>BT</th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>0</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>P1</td>
<td>0</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>P2</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
```

**Gantt chart:**

```
0 10 26 46
P2 P0 P1
```

Avg WT = \{(WT(P0) + WT(P1) + WT(P2))/3 = (10 + 26 + 0)/3 = 36/3 = 12 ms

12
25. Consider the following ANSI C function:
```
int SimpleFunction(int Y[], int n, int x)
{
    int total = Y[0], loopIndex;
    for (loopIndex=1; loopIndex<= n-1; loopIndex++)
        total = x * total + y[loopIndex];
    return total;
}
```
Let Z be an array of 10 elements with Z[i]=1, for all i such that 0 ≤ i ≤ 9. The value returned by SimpleFunction(Z, 10, 2) is _______.

Ans. 1023
Sol. (1023)
```
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>x</td>
<td>10</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

\[ V_{ar} = 1 \]
\[ \text{Total} = 1 \times 2 + 1 = 3 \]
\[ V_{ar} = 2 \]
\[ \text{Total} = 3 \times 2 + 1 = 7 \]
\[ V_{ar} = 3 \]
\[ \text{Total} = 7 \times 2 + 1 = 15 \]
\[ V_{ar} = 4 \]
\[ \text{Total} = 15 \times 2 + 1 = 31 \]
\[ V_{ar} = 5 \]
\[ \text{Total} = 31 \times 2 + 1 = 63 \]
\[ V_{ar} = 6 \]
\[ \text{Total} = 63 \times 2 + 1 = 127 \]
\[ V_{ar} = 7 \]
\[ \text{Total} = 127 \times 2 + 1 = 255 \]
\[ V_{ar} = 8 \]
\[ \text{Total} = 255 \times 2 + 1 = 511 \]
\[ V_{ar} = 9 \]
\[ \text{Total} = 511 \times 2 + 1 = 1023 \]

Final value of Total = 1023

26. Let G = (V, E) be an undirected unweighted connected graph. The diameter of G is defined as:
\[ \text{diam} (G) = \max_{u,v \in V} \text{the length of shortest path between } u \text{ and } v \]
Let M be the adjacency matrix of G.
Define graph G₂ on the same set of vertices with adjacency matrix N, where Define graph G₂ on the same set of vertices with adjacency matrix N, where
\[
N_{ij} = \begin{cases} 
1 & \text{if } M_{ij} > 0 \text{ or } P_{ij} > 0, \\
0 & \text{otherwise}
\end{cases}
\]
where \( P = M^2 \)
Which one of the following statements is true?
A. \( \lfloor \text{diagN} / 2 \rfloor < \text{diam} (G₂) < \text{diam}(G) \)
B. \( \text{diam}(G₂) = \text{diam}(G) \)
C. \( \text{diam}(G) = \text{diam}(G₂) \leq 2 \text{diam}(G) \)
D. \( \text{diam}(G₂) \leq \lfloor \text{diam}(G) / 2 \rfloor \)

[MCQ]

Ans. D
Sol.

We have the following adj matrix for this
```
\[
M = \begin{bmatrix} 
0 & 1 & 0 \\
1 & 0 & 1 \\
0 & 1 & 0 
\end{bmatrix}
\]
\[
M^{2} = \begin{bmatrix} 
1 & 0 & 1 \\
0 & 2 & 0 \\
1 & 0 & 1 
\end{bmatrix}
\]
\[
P = \begin{bmatrix} 
1 & 1 & 1 \\
1 & 1 & 1 \\
1 & 1 & 1 
\end{bmatrix}
\]

By looking at this we can say that we have Diameter \( (G₂) = 1 \).
Now by looking at these values we can eliminate options A, B, C and option D is satisfied only.

27. Consider the following three functions.
\[ f₁ = 10^n \quad f₂ = n^{\log n} \quad f₃ = n^\sqrt{n} \]
Which one of the following options arranges the function in the increasing order of asymptotic growth rate?
A. \( f₂, f₁, f₃ \)  
B. \( f₃, f₂, f₁ \)  
C. \( f₂, f₃, f₁ \)  
D. \( f₁, f₂, f₃ \)

[MCQ]
Ans. C
Sol. Take log on all functions
\[ \log(10^n), \quad \log(n^{\log n}), \]
\[ \log(n^{\sqrt{n}}) \]
\[ = n, \quad \log n, \quad \sqrt{n} \log n \]
\[ \Rightarrow f_1 < f_2 < f_3 \]

28. Consider the following matrix.
\[
\begin{pmatrix}
0 & 1 & 1 & 1 \\
1 & 0 & 1 & 1 \\
1 & 1 & 0 & 1 \\
1 & 1 & 1 & 0 \\
\end{pmatrix}
\]
The largest eigenvalue of the above matrix is _____.

Ans. 3
Sol. Let \( B = A + I \)
\[
\begin{pmatrix}
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
\end{pmatrix}
\]
All rows are identical
Only 1 independent row
So, rank of \( B \) = 1
Also, rank = Number of nonzero eigenvalues = 1
So, eigen values of \( B \) = \( \lambda, 0, 0, 0 \)
And \( \lambda + 0 + 0 + 0 = \text{trace} = 1 + 1 + 1 + 1 \)
So, \( \lambda = 4 \)
\( B \to 4, 0, 0, 0 \)
\( A \to B - I \to 3, -1, -1, -1 \)
Maximum eigen value = 3

29. A TCP server application is programmed to listen on port number \( P \) on host \( S \). A TCP client is connected to the TCP server over the network.
Consider that while the TCP connection was active, the server machine \( S \) crashed and rebooted.
Assume that the client does not use the TCP keepalive timer.
Which of the following behaviors is/are possible?
A. If the client sends a packet after the server reboot, it will receive a FIN segment.
B. If the client sends a packet after the server reboot, it will receive a RST segment.
C. The TCP server application on \( S \) can listen on \( P \) after reboot.
D. If the client was waiting to receive a packet, it may wait indefinitely.

[MSQ]
Ans. B, C, D
Sol. Option 1 is False: Server reply with RST packet not with FIN.
Option 2 is True: When server host reboots after crashes, its TCP loses all the information about connection that existed before the crash. Therefore, the server TCP responds to the receiver data segment from the client with all RST.
Option 3 is True: TCP can listen to same port number even after reboot. For example, the HTTP server application usually listen port number 80 for incoming request so even after the reboot port 80 is assigned to HTTP.
Option D is correct.

30. Consider the following pseudocode, where \( S \) is a semaphore initialized to 5 in line #2 and counter is a shared variable initialized to 0 in line#1. Assume that the increment operation in line#7 is not atomic.
1. int counter = 0
2. Semaphore \( S = \text{init}(5) \);
3. void parop(void)
4. {
5. wait(S);
6. wait(S);
7. counter++; 
8. signal(S);
9. signal(S);
10. }
If five threads execute the function \( \text{parop} \) concurrently, which of the following program behavior(s) is/are possible?
A. The value of counter is 0 after all the threads successfully complete the execution of \( \text{parop} \).
B. The value of counter is 1 after all the threads successfully complete execution of parop.
C. The value of counter is 5 after all the threads successfully complete the execution of parop.
D. There is a deadlock involving all the threads.

[MSQ]

Ans. B, C, D

Sol.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Wait(s)</td>
<td>1. Wait(s)</td>
<td>1. Wait(s)</td>
<td>1. Wait(s)</td>
<td>1. Wait(s)</td>
</tr>
<tr>
<td>2. Wait(s)</td>
<td>2. Wait(s)</td>
<td>2. Wait(s)</td>
<td>2. Wait(s)</td>
<td>2. Wait(s)</td>
</tr>
<tr>
<td>4. Signal(s)</td>
<td>4. Signal(s)</td>
<td>4. Signal(s)</td>
<td>4. Signal(s)</td>
<td>4. Signal(s)</td>
</tr>
<tr>
<td>5. Signal(s)</td>
<td>5. Signal(s)</td>
<td>5. Signal(s)</td>
<td>5. Signal(s)</td>
<td>5. Signal(s)</td>
</tr>
</tbody>
</table>

Initial S value = 5.
- If we take Preemption after 1st wait operation, in each process, then all process gets blocked, Hence Deadlock state.
- If all Programs complete Successfully, all counter++ statements execute and Prints value 10 after Execution.

OR

The given code allows up to 2 threads to be in the critical section as the initial value of semaphore is 5 and 2 wait operations are necessary to enter the critical section ([5/2]=2).

In the critical section the increment operation is not atomic. So, multiple threads entering the critical section simultaneously can cause race condition.
C. Assume that the 5 threads execute sequentially with no interleaving then after each thread ends the counter value increments by 1. Hence after 5 threads finish, counter value will be incremented 5 times from 0 to 5. Possible.
B. Let’s assume that a process used 2 waits and reads the counter value and didn’t update the value yet, all the other process let’s say the other processes executed sequentially incremented and stored the value as 4 but since the value isn’t written the first process yet the current value is overwritten by the first process as 1. Possible

D. Assume that all the process use up the first wait operation, the semaphore value will now become zero and deadlock would’ve occurred. Possible Hence Option B, C, D are correct.

31. Consider the following recurrence relation.

\[ T(n) = \begin{cases} \frac{T(n)}{2} + \frac{T(2n)}{5} + 7n & \text{if } n > 0 \\ 1 & \text{if } n = 0 \end{cases} \]

Which one of the following options is correct?
A. \( T(n) = \Theta((\log n)^{5/2}) \)
B. \( T(n) = \Theta(n) \)
C. \( T(n) = \Theta(n \log n) \)
D. \( T(n) = \Theta(n^{5/2}) \)

[MCQ]

Ans. B

Sol. Given, recurrence relation can be written as,

\[ T(n) = T(n/2) + T(2n/5) + 7n \]

Since, sum of numerator \((5/2+2 = 4.5)\) is less than denominator \((5)\), so time complexity would be function itself.
Hence, \( T(n) = \Theta(7n) = \Theta(n) \)

32. Consider the following statements.

S\(_1\): The sequence of procedure calls corresponds to a preorder traversal of the activation tree.
S\(_2\): The sequence of procedure returns corresponds to a postorder traversal of the activation tree.

Which one of the following options is correct?
A. S\(_1\) is true and S\(_2\) is true
B. S\(_1\) is true and S\(_2\) is false
C. S\(_1\) is false and S\(_2\) is true
D. S\(_1\) is false and S\(_2\) is false

[MCQ]

Ans. A

Sol. S\(_1\): Function calling sequence follows Pre-order
S\(_2\): Function return sequence follows Post-order
S\(_1\): Functions will be called in the order of definition. So, It follows Pre order sequence as FIFO.
S\(_2\): The last function call, returns control to it’s caller, that in turn returns to it’s caller and so on. So, it is LIFO order and is Equivalent to Post order traversal.
33. Consider the following two statements.
S₁: Destination MAC address of an ARP reply is a broadcast address.
S₂: Destination MAC address of an ARP request is a broadcast address.
Which one of the following choices is correct?
A. Both S₁ and S₂ are true.
B. S₁ is true and S₂ is false.
C. S₁ is false and S₂ is true.
D. Both S₁ and S₂ are false.

Ans. C
Sol. ARP request is broadcasting
ARP reply is unicasting
So, I is False.
II is true.

34. A binary search T contains n distinct elements. What is the time complexity of picking an element in T that is smaller than the maximum element in T?
A. Θ(n)  
B. Θ(log n)  
C. Θ(n log n)  
D. Θ(1)

Ans. D
Sol. To find smaller than maximum element, it may take O(n) in worst case if elements are duplicate.

35. A relation R is said to be circular if aRb and bRc together imply cRa.
Which of the following options is/are correct?
A. If a relation S is reflexive and symmetric, then S is an equivalence relation.
B. If a relation S is reflexive and circular, then S is an equivalence relation.
C. If a relation S is circular and symmetric, then S is an equivalence relation.
D. If a relation S is transitive and circular, then S is an equivalence relation.

Ans. B
Sol. A relation S is reflexive and circular
⇒ Symmetry let (a, b) ∈ S, (a, b ∈ A)
Since S is reflexive
(b, b) ∈ S
Since S is circular and (a, b) ∈ S and (b, b) ∈ S
(b, a) ∈ S
Thus S is a symmetric relation (since (b, a) ∈ S whenever (a, b) ∈ S)
⇒ Transitivity Let (a, b) ∈ S and (b, c) ∈ S
Since S is circular :
(c, a) ∈ S
we have already shown that S is symmetric, thus let use the S is symmetric :
(a, c) ∈ S
Thus S is a transitive relation (since (a, c) ∈ s whenever (a, c) ∈ S and (b, c) ∈ S)
⇒ S is an equivalence relation, because S is reflexive, symmetric and transitive.

36. A relation r(A, B) in a relational database has 1200 tuples. The attribute A has integer values ranging from 6 to 20, and the attribute B has integer values ranging from 1 to 20. Assume that the attribute A and B are independently distributed.
The estimated number of tuples in the output of σ(A>10) v (B=18)(r) is _______.

Ans. 820
Sol. P(A>10)=10/15=2/3
P(B=18)=1/20
P(A>10 ∨ B=18)=2/3 × 1/20 = 1/30
=2/3+1/20–1/30 = (40+3–2) /60= 41/60
Thus, Estimated number of tuples = (41/60) × 1200 = 820

37. A sender (S) transmits a signal, which can be one of the two kinds: H and L with probabilities 0.1 and 0.9 respectively, to a receiver (R).
In the graph below, the weight of edge (u, v) is the probability of receiving v when u is transmitted, where u, v ∈ {H, L}. For example, the probability that the received signal is L given the transmitted signal was H, is 0.7.

If the received signal is H, the probability that the transmitted signal was H (rounded to 2 decimal places) is ________? [NAT]

Ans. 0.04
Sol. Signal H can be received in 2 ways-
H was sent and H was received
L was sent and H was received
Thus, P(H received) = P(L sent)*P(H received/ L sent) + P(H sent)*P(H received/H sent)
= 0.9*0.8 + 0.1*0.3 = 0.75
Therefore,
P(Hsent/H received) = (P(H sent)*P(H received/H sent))/(P(L sent)*P(H received/L sent) + P(H sent)*P(H received/H sent)) = 0.03/0.75 = 0.04

38. Consider the sliding window flow-control protocol operating between a sender and a receiver over a full-duplex error-free link. Assume the following:
• The size of the data frame is 2,000 bits and the size of the acknowledgement frame is 10 bits.
• The link data rate in each direction is 1 Mbps (= 106 bits per second)
• One way propagation delay of the link is 100 milliseconds.
The minimum value of the sender's window size in terms of the number of frames, (rounded to the nearest integer) needed to achieve a link utilization of 50% is ________

[NAT]

Ans. 51
Sol. Tα(tata) = L = 2000 bits/ B = 10^6 bits/sec = 2 × 10^{-3} sec = 2 Msec
Tα(Ack) = Ack size/ B = 10 bits/ 10^6 bits/sec = 10^{-5} sec = 10^{-2}
Msec = 1/100 Msec = 0.1 Msec
Efficiency (η) = use fuel time/ total time
1/ 2 = N × Tα
RTT
1/ 2 = N × 2 / Td(data) + 2 × Pd + Td(Ack)
4N = 202.01
N = 50.50
N = 51 Packet

39. Consider a dynamic hashing approach for 4-bit integer keys:
1. There is a main hash table of size 4.
2. The 2 least significant bits of a key is used to index into the main hash table.
3. Initially, the main hash table entries are empty.
4. Thereafter, when more keys are hashed into it, to resolve collisions, the set of all keys corresponding to a main hash table entry is organized as a binary tree that grows on demand.
5. First, the 3rd least significant bit is used to divide the keys into left and right subtrees.
6. To resolve more collisions, each node of the binary tree is further sub-divided into left and right subtrees based on the 4th least significant bit.
7. A split is done only if it is needed, i.e., only when there is a collision.

Consider the following state of the hash table.

Which of the following sequences of key insertions can cause the above state of the hash table (assume the keys are in decimal notation)?

A. 9, 5, 10, 6, 7, 1
B. 9, 5, 13, 6, 10, 14
C. 10, 9, 6, 7, 5, 13
D. 5, 9, 4, 13, 10, 7

**[MSQ]**

**Ans.** C

**Sol.** Option A:

**Option B:**

**Option C:**

**Option D:**

Thus, C is the correct answer.

40. The lifetime of a component of a certain type is a random variable whose probability density function is exponentially distributed with parameter 2. For a randomly picked component of this type, the probability that its lifetime exceeds the expected lifetime (rounded to 2 decimal places) is _________.

**[NAT]**

**Ans.** 0.37

**Sol.**

\[ P(x) = \lambda e^{-\lambda x} \]

\[ \lambda = 2, \quad e(x) = \frac{1}{2} \implies 0.5 \]

\[ P\left(x \geq \frac{1}{2}\right) = e^{-2 \cdot \frac{1}{2}} - e^{-2 \cdot \frac{1}{2}} \]

\[ e^{-2 \cdot \frac{1}{2}} \approx 0.3678 \]

41. Consider the following Boolean expression.

\[ F = (X + Y + Z)(X' + Y)(Y' + Z) \]

Which of the following Boolean expressions is/are equivalent to \( F' \) (complement of \( F \))? 

A. \( XY' + Z' \) 
B. \( (X + Z') (Y' + Z') \) 
C. \( (X' + Y' + Z') (X + Y') (Y + Z') \) 
D. \( XY'YZ' + X'Y'Z' \)

**[MSQ]**

**Ans.** A,B,D

**Sol.**

\[ F = (x + y + z) (\bar{x} + y)(\bar{y} + z) \]

\[ F = \bar{x}y\bar{z} + x\bar{y} + y\bar{z} \]

We can plot 0’s in K-map to get minimized.

\[ F = \bar{z} + z\bar{y} \]

\( \bar{z} + x\bar{y} \) can also be written as 

\((\bar{x} + x)(\bar{z} + \bar{y})\) using distributive law.

So, option A, B and D are correct.
42. In an undirected connected planar graph $G$, there are eight vertices and five faces. The number of edges in $G$ is_______  

**Sol.**  
\[ |V| - |E| + |F| = 2 \]  
Here, $|V| = 8$, $|E| = ？$, $|F| = 5$  
$8 - |E| + 5 = 2$  
$|E| = 11$  

43. Consider the following statements.  
S\(_1\): Every SLR(1) grammar is unambiguous but there are certain unambiguous grammars that are not SLR(1).  
S\(_2\): For any context-free grammar, there is a parser that takes at most $O(n^3)$ time to parse a string of length $n$.  
Which one of the following options is correct?  
A. $S_1$ is true and $S_2$ is false  
B. $S_1$ is false and $S_2$ is false  
C. $S_1$ is false and $S_2$ is true  
D. $S_1$ is true and $S_2$ is true  

**Ans.** D  
**Sol.** $S_1$: Every SLR(1) is unambiguous but there are certain unambiguous grammars that are not SLR(1).  
$S_1$ is True.  
Every SLR is unambiguous but unambiguous need not be SLR.  
$S_2$: For any F = G, there is a parser that takes at most $O(n^3)$ time to parse a string of length $n$.  
$S_2$ is True.  
CYK algorithm exist to parse a string of length $n$ in $O(n^3)$. Bottom-up parser exist.  

44. Suppose that $L_1$ is a regular language and $L_2$ is a context-free language. Which one of the following Languages is NOT necessarily context-free?  
A. $L_1 \cdot L_2$  
B. $L_1 - L_2$  
C. $L_1 \cup L_2$  
D. $L_1 \cap L_2$  

**Ans.** [MCQ]  
**Sol.** $L = \{a^m b^n | m > n \geq 0\}$  
No. of 100 lengths are accepted by given PDA:  
m + n = 100 and m > n  
m = 100, n = 0 $\rightarrow$ $a^{100}$  
m = 99, n = 1 $\rightarrow$ $a^{99}b^1$  
m = 98, n = 2 $\rightarrow$ $a^{98}b^2$  
m = 51, n = 49 $\rightarrow$ $a^{51}b^{69}$  
Total strings = 50
46. Consider the following language.
\[ L = \{ w \in \{0, 1\}^* | w \text{ ends with the substring 011} \} \]
Which one of the following deterministic finite automata accepts L?

A. ![Automaton A]

B. ![Automaton B]

C. ![Automaton C]

D. ![Automaton D]

[MCQ]

Ans. D

Sol. L = \{ w \in \{0, 1\}^* | w \text{ ends with substring all} \}

47. Let the representation of a number in base 3 be 210.
What is the hexadecimal representation of the number?

A. D2
B. 21
C. 528
D. 15

[MCQ]

Ans. D

Sol. \[(210)_3 = ( )_{16}\]
\[2 \times 3^2 + 1 \times 3^1 = (21)_{10}\]
\[16 \frac{21}{1 - 5} + \]
\[(15)_{16}\]

48. A five-stage pipeline has stage delays of 150, 120, 150, 160 and 140 nanoseconds. The registers that are used between the pipeline stages have a delay of 5 nanoseconds each.
The total time to execute 100 independent instructions on this pipeline, assuming there are no pipeline stalls, is ____________nanoseconds.

[NAT]

Ans. 17160

Sol. Clock cycle to be provided is
\[\text{Max 150, 120, 150, 160 and 140)}\]
Which is 160 nano-seconds.
Pipeline stage Delay = 5 nsec
Total delay for one instruction in pipeline is 165 nsec
Formula : \[(k + n -1) \times \text{Delay}\]
Here \(K = 5, n = 100,\)
Delay = 165
Total time = \[(5 + 100 - 1) \times 165 = 17,160\]

49. Consider a computer system with a byte addressable primary memory of size \(2^{32}\) bytes.
Assume the computer system has a direct-mapped cache of size 32 KB (1 KB = \(2^{10}\) bytes), and each cache block is of size 64 bytes. The size of the tag field is______bits.

[NAT]

Ans. 17

Sol. For direct mapping, the address is divided as follows

\[
\begin{array}{ccc}
\text{TAG} & \text{Block-offset} & \text{Byte-offset} \\
17 & 9 & 6 \\
\end{array}
\]

Number of blocks
\[
\frac{\text{Cache size}}{\text{Block size}} = \frac{32 \text{ kB}}{64 \text{ B}} = \frac{2^{15}}{2^6} = 2^9
\]
9 bits for block offset, 6 bits for byte offset (As it has \(2^6\) bytes block)
TAG = \[32 - (9 + 6) = 17\text{ bits.}\]
50. Consider two hosts P and Q connected through a router R. The maximum transfer unit (MTU) value of the link between P and R is 1500 bytes, and between R and Q is 820 bytes. A TCP segment of size 1400 bytes was transferred from P to Q through R, with IP identification value as 0x1234. Assume that the IP header size is 20 bytes. Further, the packet is allowed to be fragmented, i.e., Don't Fragment (DF) flag in the IP header is not set by P. Which of the following statements is/are correct? A. If the second fragment is lost, P is required to resend the whole TCP segment. B. If the second fragment is lost, R will resend the fragment with the IP identification value Ox1234. C. Two fragments are created at R and the IP datagram size carrying the second fragment is 620 bytes. D. TCP destination port can be determined by analyzing only the second fragment.

**Ans.** A, C  
**Sol.** Correct answer is A and C. If any fragment lost then sender will resend all the fragment. Destination port address can also be obtained from the 1st Fragment.

51. Consider the following array.

| 23 | 32 | 45 | 69 | 72 | 73 | 89 | 97 |

Which algorithm out of the following options uses the least number of comparisons (among the array elements) to sort the above array in ascending order?  
A. Merge sort  
B. Insertion sort  
C. Selection sort  
D. Quicksort using the last element as pivot.

**Ans.** B  
**Sol.** If elements are already in sorted order then insertion sort takes less comparisons.

52. Suppose a database system crashes again while recovering from a previous crash. Assume checkpointing is not done by the database either during the transactions or during recovery. Which of the following statements is/are correct? A. The system cannot recover any further. B. The same undo and redo list will be used while recovering again. C. The database will become inconsistent. D. All the transactions that are already undone and redone will not be recovered again.

**Ans.** B  
**Sol.** Assuming undo/redo list are persistent, the answer should be B, while undo/redo system records any changes done. So, if the system crashes during recovery, the next recovery will take DB into a consistent state.

53. Consider the following sequence of operations on an empty stack. push(54); push(52); pop(); push(55); push(62); s = pop();  
Consider the following sequence of operations on an empty queue. enqueue (21); enqueue (24); dequeue(); enqueue (28); enqueue (32); q = dequeue();  
The value of s + q is _______.

**Ans.** 86  
**Sol.** Stack:

```
S = POP() ← 62 ← Push 62
POP ← 56 ← Push 56
52 ← Push 52
```

Queue:

```
s = 62
```
54. Consider the relation R(P, Q, S, T, X, Y, Z, W) with the following functional dependencies. 

\[ PQ \rightarrow X; P \rightarrow YX; Q \rightarrow Y; Y \rightarrow ZW \]

Consider the decomposition of the relation R into the constituent relations according to the following two decomposition schemes.

\[ D_1 : R = [(P, Q, S, T); (P, T, X); (Q, Y); (Y, Z, W)] \]
\[ D_2 : R = [(P, Q, S); (T, X); (Q, Y); (Y, Z, W)] \]

Which one of the following options is correct?

A. Both \( D_1 \) and \( D_2 \) are lossless decompositions.
B. Both \( D_1 \) and \( D_2 \) are lossy decompositions.
C. \( D_1 \) is a lossless decomposition, but \( D_2 \) is a lossy decomposition.
D. \( D_1 \) is a lossy decomposition, but \( D_2 \) is a lossless decomposition.

**[MCQ]**

**Ans.** C

**Sol.**

\[ PQ \rightarrow X, \quad P \rightarrow YZ, \quad Q \rightarrow Y, \quad Y \rightarrow ZW \]

\[ D_1 : (PQSTXYZW) \quad (PQST)^* = (PQSTXYZW) \quad \text{(here Y is a key)} \]

\[ D_1 \] is a lossless decomposition.

\[ D_2 : (PQSTXYZW) \quad (QY) = (QYZW) \quad (Q) = (QYZW) \quad (Q) \text{ is a key} \]

\[ D_2 \] is a lossless decomposition.

55. Consider the following grammar (that admits a series of declarations, followed by expressions) and the associated syntax directed translation (SDT) actions, given as pseudo-code:

\[ P \rightarrow D^* E^* \]
\[ D \rightarrow \text{int} \ ID \ \{\text{record that ID.lexeme is of type int}\} \]
\[ D \rightarrow \text{bool} \ ID \ \{\text{record that ID.lexeme is of type bool}\} \]
\[ E \rightarrow E_1 + E_2 \ \{\text{check that } E_1.\text{type = E}_2.\text{type = int; set E.type := int}\} \]
\[ E \rightarrow \!E_1 \ \{\text{check that } E_1.\text{type = bool; set E.type = bool}\} \]
\[ E \rightarrow \text{ID} \ \{\text{set E.Type := int}\} \]

With respect to the above grammar, which one of the following choices is correct?

A. The actions can be used to type-check syntactically correct integer variable declarations and integer expressions.
B. The actions can be used to correctly type-check any syntactically correct program.
C. The actions can be used to type-check syntactically correct Boolean variable declarations and Boolean expressions.
D. The actions will lead to an infinite loop.

**[MCQ]**

**Ans.** A

**Sol.**

\[ E \rightarrow \!E_1 \ \{\text{If } E_1.\text{type = int then E.type bool}\} \]

**Note:** Here instead of int, it is given as bool.

All actions can be used to type check syntactically correct integer variable declaration and integer expressions.
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